# Beryllium Control Model

## Atomic Weapons Establishment

## Cardiff

Prepared by

Atomic Weapons Establishment, Cardiff, U.K.

and

U.S. Department of Energy

June 25, 1997

# FOREWORD

The beryllium facility of the Atomic Weapons Establishment, Cardiff, in the United Kingdom, as managed by Hunting-BRAE, Ltd., trading under the name of AWE, acting on behalf of the United Kingdom Ministry of Defense, is a model of successful management of beryllium hazards. Cardiff maintained exposures to beryllium as low as practicable from the beginning of manufacturing operations in 1960 until ceasing operations in February 1997. The facility found no cases of chronic beryllium disease among its approximately 300 beryllium employees over this 37-year period.

The AWE and the U.S. Department of Energy (DOE) have exchanged beryllium-employee protection information for several years through joint participation on the Beryllium Monitoring Committee. In March 1997 representatives of AWE gave presentations on the Cardiff experience at a Committee meeting. DOE participants, recognizing the value of the Cardiff experience as a model for successfully controlling the hazards of working with beryllium, requested the assistance of the AWE representatives in describing this model to the DOE community.

This document, the result of this collaboration between AWE and DOE, provides an overview of AWE Cardiff's experience for use by the DOE community.

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## Beryllium Control Model, Atomic Weapons Establishment (AWE), Cardiff

(Note: This document was prepared by D. Weitzman (U.S. DOE, EH-5) based on a March 17, 1997, conversation with Graham Cogbill (AWE, Cardiff, U.K.). Cardiff is the production facility, Aldermaston the research facility. The following information is about Cardiff unless otherwise noted.)


Summary

Cardiff is a beryllium production facility that conducted operations very similar to the operations that DOE's Rocky Flats conducted except that Cardiff's output was smaller. Cardiff maintained exposures to beryllium as low as practicable from the beginning of their operations in 1960 until ceasing manufacturing operations in February 1997. They experienced no cases of chronic beryllium disease among their approximately 300 beryllium employees over this 37-year period.


History

Cardiff has had approximately 300 employees who could be considered beryllium employees over their 37 years of operations. This workforce has been very stable.

The beryllium facility is 5000 $m^2$. It was first built in 1960, expanded in 1976, and ceased manufacturing operations on Feb. 28, 1997. Cardiff now is engaged in deactivating and decommissioning (D&D) the facility in stages over the next 5 years. The beryllium facility was used exclusively for beryllium manufacturing. The U.K.'s remaining beryllium manufacturing is being moved to the Aldermaston facility. Some Cardiff equipment will be moved to Aldermaston after appropriate decontamination.

Cardiff operations consisted of Vacuum Hot Press, Powder Preparation-Impact Mill, Casting, Plasma Spray, Machining, and the Laboratory.

## Exposure Standards

Cardiff adopted the 8-hour time-weighted average of 2 $\mu g/m^3$ of beryllium in air, which is the same as the U.S. standard. Cardiff since 1990 had used a surface action level of 10 $\mu g/ft^2$, which triggered cleaning above and beyond routine cleaning. The surface action level was 25 $\mu g/ft^2$ prior to 1990. Cardiff routinely gathered swipe samples on a predetermined grid pattern and cleaned the surfaces having contamination levels above these triggers.

The swipe methods used by AWE facilities consistently use dry swipe filters, but other details of the methods vary between different locations. For example, Cardiff reported the result as measured but Aldermaston assumes that the filter picks up only 10 percent of the beryllium, so they multiply the measured result by 10 and report that value as their surface contamination level.

Cardiff had established 0.1 $\mu g/cm^3$ as their standard for release of waste water effluent which is significantly below the regulatory consent value of 5.0 mg/L.

Cardiff has developed standards for the D&D of their machine tools. Tools that are designated for burial will have their accessible surfaces cleaned and then have a fixitive applied. Tools that are designated for transfer to Aldermaston will be cleaned to 5 $\mu g/ft^2$.

## Controls

Cardiff controlled employee exposures to levels that are well below the 2 $\mu g/m^3$ limit. Typical airborne personal air levels in the machine shop were below 0.1 $\mu g/m^3$ to 0.2 $\mu g/m^3$. Machine shop employees did not routinely use respirators but used respirators when opening a machine enclosure to change parts. It was common to get personal air sampling levels of 0.5 -1.0 $\mu g/m^3$ in the foundry. Levels >2 $\mu g/m^3$ could occur during certain loading and unloading foundry operations but employees routinely used respirators

for these operations. In a typical year, out of over 14,000 personal air samples taken, Cardiff experienced about 10 samples over the 2 $\mu g/m^3$ limit where employees may not have been wearing respirators.

Cardiff's controls changed little since they began operations in 1960 because they adopted the "as low as reasonably practicable" approach from their radiation control program at the outset. These controls included high-velocity, low-volume exhaust and partial enclosures at generation points, glove boxes, respirator use, negative pressure zones for different areas, vacuuming or wet-washing of surfaces, change of coveralls and overshoes worn over work clothes for employees and street clothes for visitors when entering and leaving the beryllium area, and access control via a physical barrier.

Cardiff limited the number of maintenance craftpersons (about 15) and cleaners (janitors) (about 10) who worked with beryllium and were allowed into the beryllium area.

Cardiff beryllium employees wore respiratory protection when opening glove boxes or other enclosures, or when handling materials or items that may have contained, or may have been contaminated with, particulate beryllium.

Cleaners designated as beryllium employees routinely cleaned work surfaces to keep surface contamination levels low. Surface swipes were routinely taken as a quality control measure. Since 1990, cleaning above and beyond the routine cleaning was triggered by a surface level of 10 $\mu g/ft^2$; previously, the trigger had been 25 $\mu g/ft^2$. Respirators were not necessarily used for cleaning when triggered by these surface action levels. Respiratory protection was used, however, when cleaning visible spills that were presumed to contain high surface contamination levels. Employees initiated an evacuation in response to any suspect spill until a supervisor cleared the space for reoccupation.

Nothing left or was brought out of the beryllium area that was not cleaned of beryllium first. Tools were brought out only after sufficient cleaning to

achieve surface levels measured <1 µg/ft$^2$. Papers inside the beryllium area were also assumed to be beryllium contaminated. Photocopying was done on a machine at the area barrier, the copies coming out on the clean side of the barrier and the originals being retained in the beryllium area until disposed of as beryllium waste.

Cardiff will dispose of their machine tools by burial after cleaning accessible surfaces. They anticipate that air levels will be in the 0.1-0.2 µg/m$^3$ during this cleaning operation. Cardiff believes that it would not be cost effective to clean the accessible surfaces of these tools to their 1 µg/ft$^2$ standard for releasing items; they recognize that downstream users could receive exposures when accessing areas behind electrical covers and other myriad nooks and crannies. They will clean the accessible surfaces to 5 µg/ft$^2$ before releasing the machine tools that Aldermaston will take. Aldermaston will use these machine tools exclusively for beryllium.

Laundry waste water originally was collected in large tanks and periodically disposed of into the local sewer system after laboratory confirmation that the beryllium concentration was less than their 0.1 µg/cm$^3$ standard. Since the mid-1980s Cardiff used an onsite Beryllium Flocculation Plant. A polymer flocculent captured the beryllium. The beryllium containing floc was skimmed off the surface and disposed of as hazardous waste in a landfill.

Plasma spraying and the impact attrition mill were difficult operations to control. Full-face respirators were used at all times in both the plasma spraying and impact attrition mill areas. The plasma spraying operation was enclosed, but was pressurized with inert gas. There was a potential for release of beryllium if the enclosure were breached. In order to minimize the impact of a release, the suite in which plasma spraying was conducted was isolated with physical barriers and maintained under negative pressure relative to the adjacent machine shop.

Medical Surveillance

Cardiff found no cases of chronic beryllium disease among its beryllium employees. Aldermaston has found one case.

Cardiff medical surveillance consisted of monthly spirometry and hands inspection for nodules, and annual optional chest X-rays. Annual X-rays originally were mandatory but were changed to be optional at the discretion of the physician and with the consent of the employee.

Cardiff in the 1980s identified beryllium-containing nodules (granulomas) on the hands of some employees. Most of the cases were diagnosed in machinists, though some cases were diagnosed in inspectors. One worker had multiple nodules on his hands. Cardiff responded to this medical finding by initiating monthly inspections of beryllium employees' hands.

Cardiff tested an early version of the beryllium-induced lymphocyte proliferation test (Be-LPT) procedure in the mid-to-late 1980s to screen 40 employees for sensitization to beryllium. They did not continue the screening because of the inconsistency of the results obtained. AWE continues to have concerns about the reliability of the procedure even though the procedure has been improved and there are now a few U.K. hospital laboratories that are capable of performing it, which may further improve the procedure's reliability. Milt Rossman and Gail Littlefield have offered to assist AWE. The use of Be-LPT at Cardiff during their D&D operations and at Aldermaston during their manufacturing operations remains under review by AWE.

In the early 1960s, a machinist sustained a wound to his hand which subsequently required a finger to be amputated. The wound was caused by contact with a cutting wheel that was contaminated with beryllium oxide. Beryllium interfers with proper healing of wounds. A more rigorous wound cleaning protocol has been implemented over the last 30 years to ensure successful decontamination of wound sites.

Exposure Monitoring

All Cardiff beryllium employees wore a personal monitor whenever they were in the beryllium shop (i.e., every employee, every shift). The employees put on and took off the personal sampling pumps by themselves. Four technicians performed all the other pump maintenance and filter handling tasks, as well as the analysis of samples. Samples consisted of personal air, area air, surface, respirator, and water effluent.

During peak production, approximately 270 samples per shift were analyzed. A typical breakdown of these 270 samples is as follows: 80 personal air, 80 area air, 20 respirator, 80 swipe, and 10 water effluent. The numbers of samples taken over a year, and sample flow rates for the air samples, were 21,500 area air samples taken at 30 L/min, 14,400 personal air samples taken at 2 L/min, and 27,000 swipe samples.

The detection levels reported by Cardiff are as follows:

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|---|---|
| 0.05 µg/$m^3$ in air | Area air samples, measured by flame Atomic Absorption spectroscopy (AA) |
| 0.1 µg Be | Total in sample, measured by flame AA |
| 0.05 µg Be | Total in medical and personal air samples, measured by Inductive Coupled Plasma spectroscopy |

Cardiff designated 10-15 of the area samples, one sample from each of the main processing areas, as "core" samples. The results of core samples were available before resumption of work after the lunch break and before the next shift began. Investigations were conducted immediately if a source was found to be out of control from the core sample result. The Cardiff laboratory was capable of obtaining results in 35-45 minutes, but this fast turnaround was reserved for monitoring a skin wound for beryllium contamination.

## Recordkeeping

Cardiff has the largest amount of personal beryllium exposure monitoring data anywhere in the world. Their exposure data has been computerized since 1981. Lawrence Livermore National Laboratory (LLNL) has a file with >500,000 of Cardiff's post-1981 area and personal sample results in electronic format. LLNL has provided summaries of the data and has proposed to conduct detailed analyses for DOE. LLNL also has proposed to transfer the data to a more accessible database so that any interested researcher could use the data. Cardiff retains the data from 1960 to 1981 in paper records. Cardiff believes that the paper records essentially are complete but it is possible that some gaps exist.

## Performance Feedback

The Cardiff laboratory each day provided surface, area air, and personal air results to supervisors and posted the results for employees to see.

Beryllium employees were Cardiff's best "policemen" for implementing good work practices based on performance feedback. They put peer pressure on the employees found to be "dirty" based on the daily posting of surface, area air, and personal air monitoring results and on observing how these "dirty" employees performed on the shop floor.